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Managing climate change risks in global supply chains: A review and research agenda

Abstract

Climate change is forcing governments and businesses to explore mitigation strategies to avoid future catastrophe. There is an urgent need to manage climate change risks in global supply chains. Following a systematic literature review and text mining approach, 90 interdisciplinary articles between the years 2005 and 2018 were studied. Thematic and descriptive analysis identifies sources, consequences and control mechanisms for the climate change risks. It is found that climate change driven by extreme weather conditions significantly impacts food production, natural resources and transportation worldwide. This direct impact on food, mining and logistics sectors cascades into other interlinked global supply chain network. Climate change and supply chains are found to be mutually influencing each other through natural disasters and greenhouse gas (GHG) emissions respectively. A systems theory driven, novel supply chain risk management framework for managing climate change risks is proposed. The study contributes to supply chain risk management literature by capturing the nexus between climate change and supply chain management.

Keywords- Climate change, Climate risk, Supply chain risk management, Systems theory, Systematic literature review

1. Introduction

Climate change is unarguably the greatest challenge of the century and is inevitably affecting society, environment and business operations (Schneider, 2011). As per scientists studying the effects of climate change have identified that the climate change is approaching faster than predicted and now needs 'immediate action'. The exposition of climate change includes higher temperatures, altered rainfall patterns, and frequent or intense extreme weather events such as heatwaves, drought, floods, cold spells, and storms. The costs of disruption due to extreme weather conditions have increased considerably (Halldorsson and Kovacs, 2010; Ng *et al.,* 2013), posing additional challenges to today's global supply chains. Extant research on climate change within Supply Chain Management (SCM) has concentrated on calculating carbon footprint and ways to reduce greenhouse gas (GHG) emissions (McKinnon *et al.,* 2015). However, notwithstanding existing regulatory responses, climate change risks are on the rise and are significantly affecting business performance (Diabat and Simchi-Levi, 2009; Ng *et al.,* 2016). Climate change and its impact is also widely debated in global politics. In 2014, 186 countries took part in the United Nations Conference on Climate Change in Paris, where they set aspirational targets to keep global warming below 2^0C (UNFCCC, 2014). Although climate change has received considerable public and government attention thereafter; recent studies show that several participating countries are falling short of the GHG targets set in the Paris climate deal; thus, accelerating the consequences of climate change risks (Diffenbaugh *et al.,* 2018). Limited studies on adaptation/mitigation of climate change in agriculture/agri-food supply chains are evident (e.g. Powlson *et al.,* 2014; Challinor *et al.,* 2014; Burke and Emerick, 2016; Mottet *et al.,* 2017). However, comprehensive study on managing climate change and its associated risks in the global supply chains context remains unexplored (Schneider, 2011; Lee, 2011; Dasaklis and Pappis, 2013; Jira and Toffel, 2013; Fleming *et al.,* 2014). It is likely that global operations will be significantly affected by the regulations and policies introduced by different governing bodies and policy-makers to tackle this unsolved risk (Howard-Grenville *et al.,* 2014). The impact and mitigation approaches for climate change are expected to redesign business management research. A better understanding of climate change risks in the SCM context is critical for future managers (Jira and Toffel, 2013).

Despite its growing importance, literature on managing climate change risks in the supply chain context is scarce. To the best knowledge of the authors', a comprehensive study addressing the nexus between climate change and SCM is missing in the academic literature. Thus, there is an urgent need to understand the implications of climate change risks on global supply chains and ways to manage them. Following a Systematic Literature Review (SLR) the study attempts to answer the research question: *How can climate change risks be managed in global supply chains?* SLR is an evidence-based methodology to enhance the existing knowledge base (Tranfield *et al.,* 2003; Denyer and Tranfield, 2009) adapting a systematic, transparent and comprehensive review of quality sources. The SLR brings reliability, validity, coherence and completeness to the literature survey, yielding valuable information for evidence-enriched practices and policy decision-making (Rousseau et al., 2008). The SLR and Supply Chain Risk Management (SCRM) approach adopted in this paper integrates current developments and draws unique future directions. The text mining implemented for data validation brings transparency to the review process.

The paper contributes to the literature by inter-linking climate change risks with supply chains following the development of different typologies for descriptive and thematic analysis. The study examines sources and consequences of climate change risks along with control mechanisms following the Supply Chain Risk Management (SCRM) approach. A novel framework for managing climate change risks in global supply chains is developed following systems thinking approach. The study further contributes by identifying unique avenues for the future research.

The rest of the paper is structured as follows. Section 2 discusses brief terminology associated with SCRM and climate change. Section 3 presents the research methodology for identification, synthesis, analysis, and dissemination of the selected data. Section 4 discusses the descriptive assessment of the subject area following the themes developed. The thematic study conducted in section 5 attempts to capture the critical aspects of climate change risks on SCs. Section 6 establishes a framework and future research directions based on identified research gaps. Discussion and conclusion section presents contribution to theory and practice, along with limitations of the research.

2. Terminology

This section provides a brief background of two key building blocks used in this review, i.e. supply chain risk management and climate change.

2.1. Supply chain risk management

There has been no consensus on the definition of SCRM, despite multiple definitions being available within the extant literature (Sodhi *et al.,* 2012). According to Tang (2006), SCRM is "*the management of supply chain risks through coordination or collaboration amongst the supply chain partners to ensure profitability and* *continuity*". More recently, Lavastre *et al.* (2012) have defined SCRM as the way of management that includes operations and strategies both long term and short term. Meanwhile, Wieland and Marcus Wallenburg (2013) define SCRM as a method to achieve the goal of implementing strategies that result in less disruption to supply chains. The SCRM process consists of risk identification, risk assessment and risk mitigation (Kleindorfer and Saad 2005). While risk identification and the classification stage concern sources and types of risks, risk assessment is related to the likelihood and consequences of the event (Harland *et al.,* 2003). Uncertainties (in demand/supply or lead-time, etc.) increases risks in supply chains (Christopher and Lee, 2004); thus, risk occurs when there is exposure and uncertainty (Holton, 2004; Chiu and Choi 2016; Shen and Li, 2017). Both, qualitative and quantitative research methods are commonly used for risk assessment. The risk mitigation stage can be classified into proactive and reactive risk mitigation. Several studies focus on risk management and SC decision-making in response to unpredictable disruptions. These risks can be mitigated by establishing strategic supplier relationships (Hajmohammad and Vachon, 2015; Chen *et al.,* 2015) and using business continuity planning as a risk management technique (Sahebjamnia *et al.,* 2015). It is evident that SCRM is a prerequisite to improving the stability of today's supply chains (Wieland and Marcus Wallenburg, 2012).

2.2. Climate change

Climate change is defined as "*a change in the state of the climate that can be identified by changes in the mean and variability of its properties and persists for extended periods decades or longer*" (IPCC, 2000). Climate change associated events are extreme weather conditions such as heat waves, floods, storms and droughts (Easterling *et al.,* 2000). Changes to seasons, water resources, ocean acidification, and coastal flooding are direct consequences of climate change (Howard-Grenville *et al.,* 2014). There is a growing recognition that climate change-related events can pose serious financial risks to global industry sectors (Nikolaou *et al.,* 2015). Governments and organizations have recognized the need to adopt policies and procedures to mitigate climate change risks (Nema *et al.,* 2012; Pappis, 2010). There is an urgent need for developing analytical models to manage the impact of climate change (Stern, 2016). To develop smart models, first step is to collect and share fundamental information on climate change interfacing global supply chains (Levermann, 2014).

3. Research Methodology

The information explosion from multiple data sources makes it difficult to identify explicit and justifiable knowledge about the research area (Ghadge *et al.,* 2012). Such a wealth of information (big data) needs a robust process for selection, assessment and dissemination to develop future research insights. The systematic literature review (SLR) is recognised as a well-defined process that has an explicit search strategy following the identification of '*keywords*' or '*search strings*'. The development and application of the predefined inclusion and exclusion criteria ensure that the results are objective and unbiased (Tranfield *et al.,* 2013).

The SLR process is considered to be time-consuming, labour intensive and '*mechanical*' in its operation. To overcome some of the weaknesses in SLR, this study applies data mining approach to enhance the quality of data synthesis and analysis. A step-by-step approach for three crucial stages is presented along with the list of activities undertaken at each stage of the SLR (Figure 1).

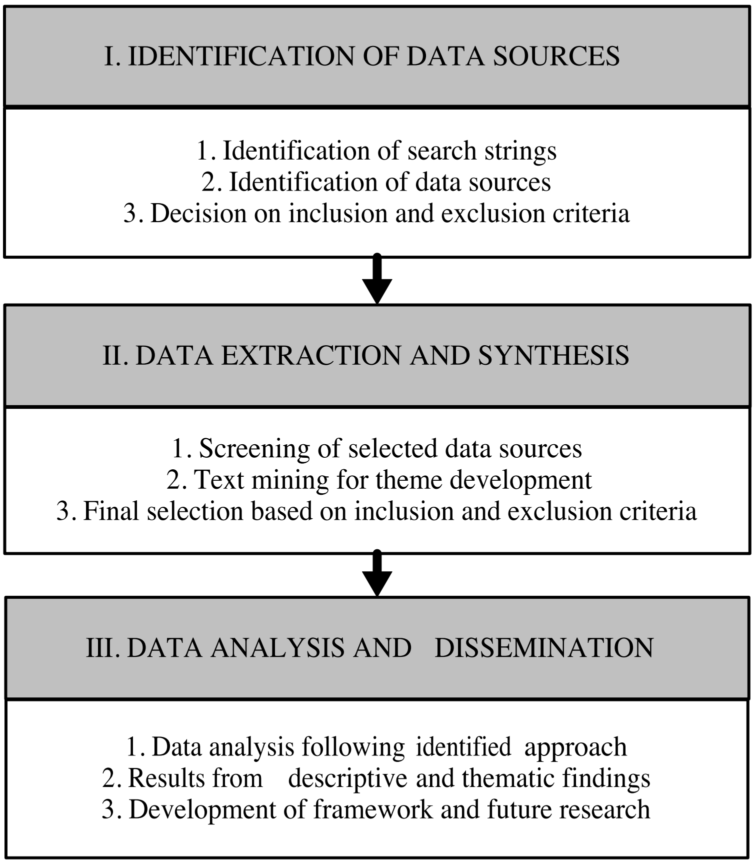

Figure 1. Systematic literature review process (Adapted from Tranfield *et al.,* 2003)

3.1. Data identification

Data identification is an iterative process that includes selecting relevant sources following appropriate keywords. It is necessary to assess the importance of the literature and to delimit it by considering cross-disciplinary perspectives (Tranfield *et al.,* 2003).

In the primary process, two keywords '*climate change*' and '*supply chain**' were used together through a '*Boolean logic'* to search the academic database. This approach was followed, firstly, to identify the data sources which cover SCs in the context of climate change and, secondly, to identify other associated search strings for comprehensive identification of the data sources. The pilot bibliometric search was conducted in April 2017 and concluded with 788 results matching the keywords/search strings. In the secondary process, alternative keywords were identified by cross-referencing and scanning the preliminary literature. In total, 19 search strings were identified and further reduced to 10 following a Delphi study conducted in May 2017. Delphi study helps to capture a holistic view of the subject, following the involvement of a geographically and professionally diverse pool of experts (Linstone and Turoff, 1975). Seven academic researchers (each with a doctorate and average academic/industry experience around 5-10 years) from the interdisciplinary field (three from the SCM field, two from Environmental Science, three from Business and Policy) participated in the Delphi study. The participants were asked to select their top 10 search strings based on their experience in the relevant fields. The iterative process of the Delphi study led to the final list of search strings as shown in Table 1.

Two primary academic databases namely *SCOPUS* and *Web of Science* were then used to identify the peer-reviewed, high quality (based on ranking, citations, impact factor, etc.) journals. Both the databases are commonly used for screening of data sources and are proven to provide reasonably comprehensive results (Harzing and Alakangas, 2016). Following 10 top search strings both databases were extensively searched (starting year 2005) and filtered in June 2017. Denyer and Tranfield (2009, p.680) stress that the inclusion of a broad spectrum of studies in the SLR can "*compensate for researcher value judgements and uncontrolled validity threats*". Hence, it was decided to include inter-disciplinary studies rather than studies that were limited only to the SCM/OM domain, (operations and technology management, operations research, management science and general business management) to ensure a holistic and unbiased output.

The existing research on climate change within an SCM context can be broadly categorised into two different research streams (Dasaklis and Pappis, 2013). The first stream investigates carbon emission reduction while aiming at GHG cost reduction. The second research stream copes with the physical impacts of climate change on supply chains like extreme weather conditions such as storms or floods. The research utilises these insights to identify search strings, which are based on the primary drivers of climate change and their consequences.

Table 1. List of search strings used for SLR (From 2005 to Mid-2017)

Search Strings/Keywords	**SCOPUS** ***Database***	**Web of Science** ***Database***
Climate change AND supply chain*	788	664
Global warming AND supply chain*	416	245
Environmental impact* AND supply chain*	2910	2328
Carbon footprint* AND supply chain*	487	444
Carbon mile AND supply chain*	27	24
Greenhouse gas* AND supply chain*	717	645
CO_2 emission* AND supply chain*	447	469
Natural disaster* AND supply chain*	298	198
Extreme weather AND supply chain*	35	28
Natural resource* AND supply chain*	874	599
Total number of hits	**6999**	**5644**

The majority of researchers from the fields of science and management would agree that human-induced CO_2 and other GHG released into the atmosphere increase the climate change risk (IPCC, 2007a; IPCC, 2007b).

3.2. Data extraction and synthesis

Data extraction and synthesis require clarity regarding the nature of the data being studied (Badger *et al.,* 2000). In the data extraction and synthesis stage, a framework for the data analysis is built, along with the key research themes identified (Rousseau *et al.,* 2007). This stage involved screening abstracts to identify relevant literature and to develop inclusion and exclusion criteria for the study. Pre-defined inclusion and exclusion criteria are believed to generate high-quality knowledge discovery (Smithey, 2012). The pre-set inclusion criteria selected only academic journals. Other academic and non-academic sources such as company reports, textbooks, book chapters, conference papers, white papers, website links were excluded from the study. This exclusion of the '*grey literature'* in SLR studies (Seuring and Müller, 2008), helps to secure a focus on the quality publications. Consequently, a total of 131 papers were selected for full assessment. Although 67 journal papers contained the selected keywords, they were found to be irrelevant for the study and hence excluded to come up with 64 journal papers fulfilling all inclusion screening criteria for data synthesis and analysis.

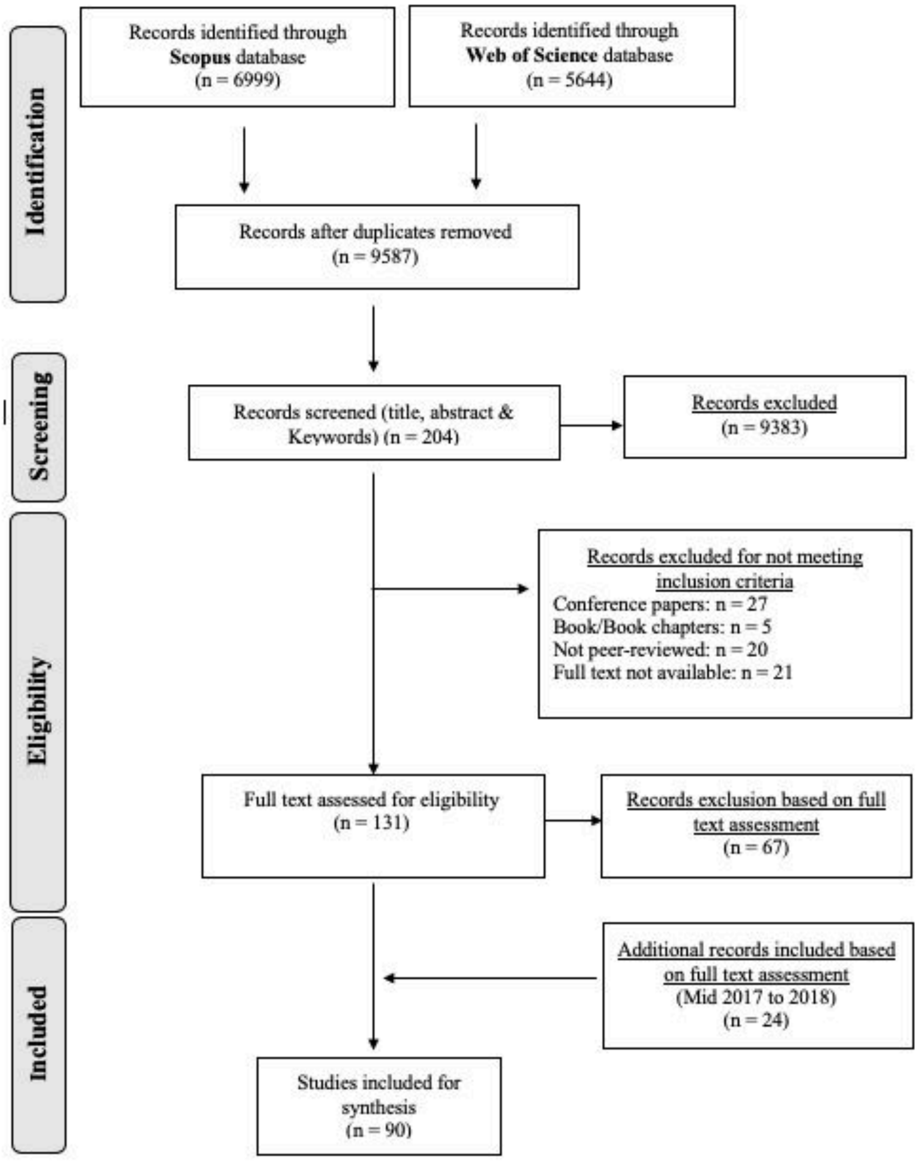

Figure 2. PRISMA flow diagram for data screening

Table 2. Keywords and phrases identified through text mining

Words	Frequency	% Cases	TF-IDF*	Phrases	Frequency	% Cases	TF-IDF*
Supply	5430	99%	350.3	Climate change	1771	74.6%	225.1
Carbon	1708	65.6%	311.9	Food safety	233	13.4%	203.1
Food	950	49.2%	292.2	Carbon emission	216	20.9%	146.9
Emissions	1749	68.6%	285.6	GHG emissions	239	31.3%	120.4
Disaster	376	19.4%	267.8	Carbon footprint	287	40.3%	113.3
Climate	2288	77.6%	251.8	Sea level	137	16.4%	107.5
Adaptation	493	31.3%	248.4	Transportation mode	90	10.4%	88.3
GHG	391	37.3%	167.4	Climate adaptation	82	8.9%	85.9
Risk	997	70.1%	153.5	Risk management	176	35.8%	78.5
Energy	870	68.6%	142.1	Natural disasters	116	26.8%	66.2
Water	770	65.6%	140.6	Logistics network	74	16.4%	58.1
Sustainability	450	55.2%	116	Climate change mitigation	93	23.8%	57.8
Transportation	660	67.1%	114.1	Sustainable supply chain	80	19.4%	57
Business	736	79.1%	74.9	Environmental impact	105	29.8%	55.1
Performance	701	79.1%	71.4	Environmental performance	131	38.8%	53.9
Natural	480	73.1%	65.2	Natural resources	98	28.3%	53.6
Consumption	408	70.1%	62.8	Global supply chain	75	22.3%	48.7
Cost	998	86.5%	62.5	Energy efficiency	92	31.3%	46.4
Policy	410	71.6%	59.4	Extreme weather	73	26.8%	41.7
Economic	813	85%	57.1	Global warming	79	41.7%	29.9

**TF-IDF is Term Frequency-inverse Data Frequency*

Since screening and analysis of the journal papers was first conducted around June 2017, in order to make this SLR most up-to-date, additional 24 papers published between July 2017 and December 2018 were included in March 2019. These additional papers were screened by applying the same inclusion and exclusion criteria and subsequent full text assessment making the final list of journal papers for data extraction and synthesis to 90. Figure 2 shows the flow diagram followed for screening the dataset adapting a PRISMA (**P**referred **R**eporting **I**tems for **S**ystematic Reviews and **M**eta-**A**nalysis) approach which is a systematic method to visualise the study selection process (Siddaway, 2014).

3.3. Data analysis and dissemination

Data analysis is divided into descriptive and thematic analysis. While the former provides a quick overview of the area by providing rough-cut, detailed analysis, the latter is a comprehensive and interpretative analysis of the research field (Tranfield *et al.,* 2003). Statistical results are used to facilitate the descriptive analysis. Thematic and descriptive analysis was conducted following a thorough review of the selected 64 inter-disciplinary journal papers from July-August 2017. Additional 24 papers included in March 2019 were analysed following mainly a thematic analysis approach.

To enhance the quality of the SLR, text mining was applied on sources to validate the search strings derived from the data identification process and to provide further support for the data analysis. *QDA Miner*©, a qualitative data analysis software developed by Provalis Research was used as a text mining platform. Table 2 presents the most important words or phrases identified in the selected database by its term frequency and inverse document frequency (TF-IDF). TF-IDF is a measure of significance and provides information regarding the number of occurrences of a given word or phrase in the selected dataset (Aizawa, 2003). Most of the identified words and phrases (refer Table 2) show a strong correlation with identified search strings. This retrospective validation of the pre-identified search strings provides confidence in the reliability of the process followed for data identification and analysis.

4. Descriptive Analysis

This section provides generic findings made for the identifed themes (presented below). Figure 3 shows the journal-wise distribution of 90 papers selected following the data screening process. In total, 45 inter-disciplinary journals contributed to the holistic nature of the study. As the SLR covers a relatively emerging area of research in General business/SC context, it is imperative to cover a broad variety of academic literature to obtain a comprehensive overview of the field, which further justifies the need for such an inter-disciplinary literature survey. Climate change related research within SC context is found to be primarily published in the *International Journal of Production Economics, International Journal of Production Research, Journal of Cleaner Production*, *International Journal of Physical Distribution & Logistics Management* and *Transportation Research Part D/E,* contributing to almost half of selected paper (45.60%). The remaining half (54.40%) of selected papers are from other interdisciplinary journals, including a few from science, technology management, management science, and general management areas.

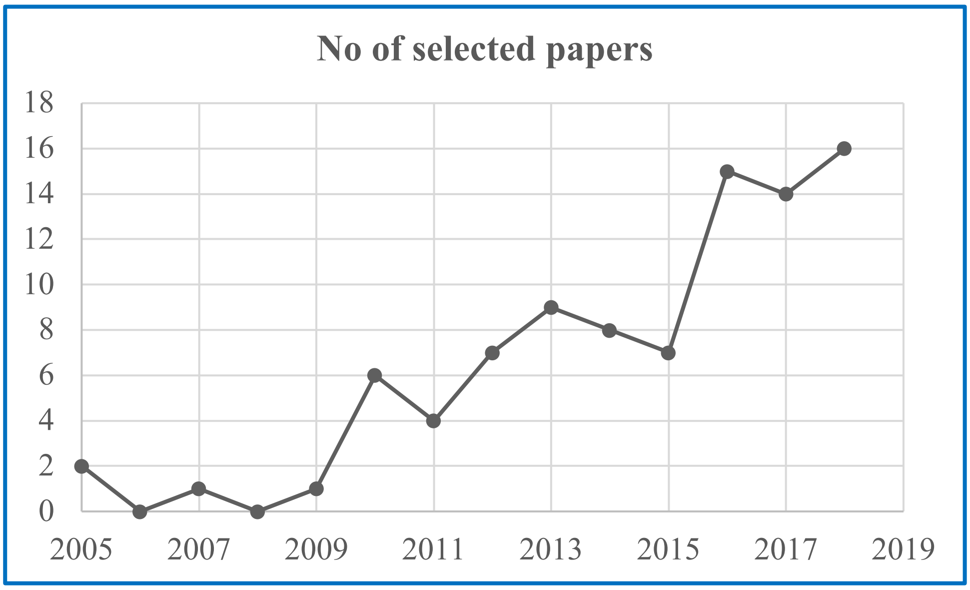

Figure 3. Year-wise distribution of selected journal papers

Figure 3 shows 90 selected journal papers published from the year (Jan.) 2005 to (Dec.) 2018. The research outputs demonstrate an upward trend from year 2010, continuing up to 2016 and beyond. This growing volume of papers represents the academic interest in this emerging research field. The author believes that since the Kyoto protocol 2005 (Lee, 2012; Wittneben and Kiyar, 2009), research on climate change has become a focal point for several inter-disciplinary researchers. The United Nations Conference on Climate Change in Paris in 2015, has probably reinforced this growth in climate change related research.

The descriptive analysis of the 90 papers was conducted following a statistical approach; Microsoft Excel and Mendeley were used to collate the information regarding each paper based on the themes identified. These themes were developed following a cluster mapping approach. Clustering is a useful technique in text mining for finding exciting themes/patterns from large unstructured data (Sivarajah *et al.,* 2017). The clustering or concept mapping technique generates a nested sequence of partitions, forms groups, and visualises the results as a tree of clusters called a '*dendrogram*' (Pons-Porrata *et al.,* 2007). Each node in the dendrogram is constructed to illustrate relationships of similarity among clusters. Figure 4 illustrates a snapshot/example of a dendrogram obtained for the subject area, following the text mining of selected papers in the qualitative data analysis software (QDA-Miner). After considering all the clusters in the dendrogram, the identified key patterns supported developing themes for the data analysis. Furthermore, sub-categories for themes emerged during the iterative process of data screening and synthesis. The themes identified for the data extraction and analysis are presented below:

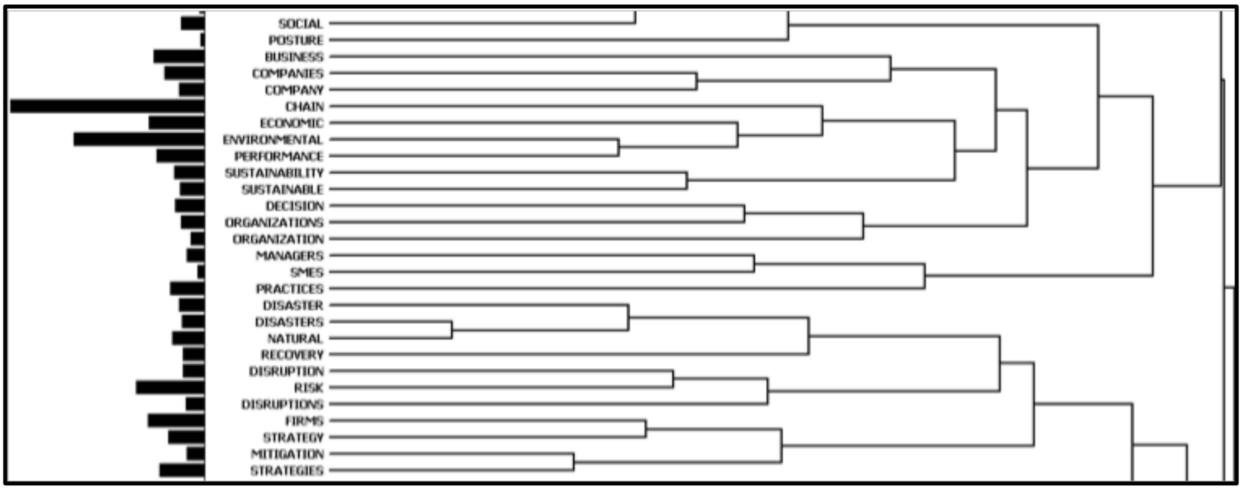

Figure 4: Concept mapping/Dendrogram (excerpt) for theme development

- ***Based on research methodology*: ** Theme to understand the risk assessment methods commonly used for climate change related issues. This provides insights into preferred research methods for the subject area.
- ***Based on industry sector:*** Theme to identify the concentration of climate change research within different industry sectors.
- ***Based on management level*: ** Theme to understand the focus of research within SCM hierarchy, i.e., strategic or operational level.

- ***Based on supply/demand side*****:** Theme to understand the focus of the existing research within SC networks. The term 'network' is used to capture both supply and demand sides in a supply chain network.
- ***Based on sources of study*****:** The research attempts to uncover internal and external perpetrators of the climate change. Sources of climate change are identified following this theme.
- ***Based on control drivers*****:** To identify the critical drivers for climate change control. Different control drivers are identified following this theme.
- ***Based on risk mitigation approach*****:** To identify the focus of a risk mitigation approach while tackling climate change issues. Risk mitigation practices within supply chains are studied following this theme.

Figure 5 presents the framework for data extraction and analysis following the identified themes.

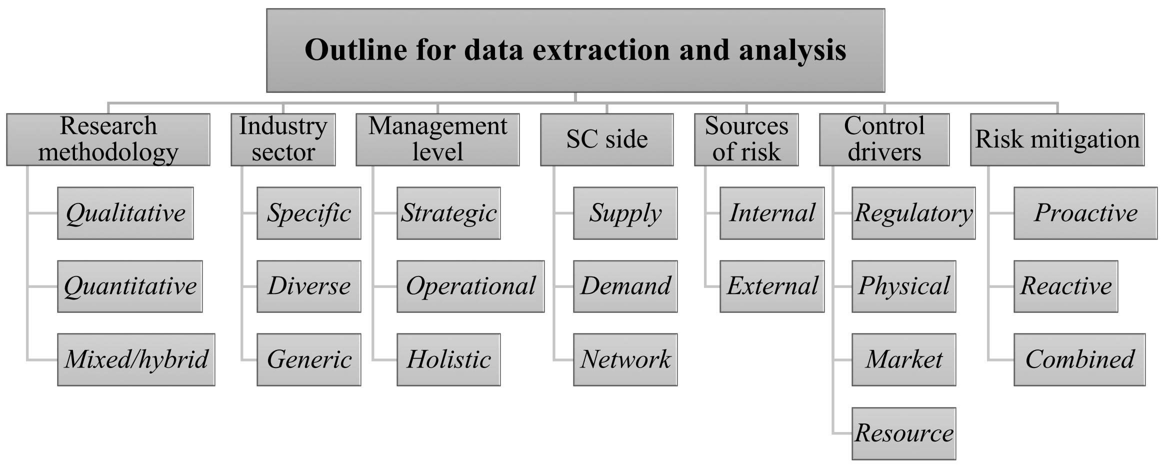

Figure 5. Framework for data extraction and analysis

4.1. Research methodology

The research methodologies can be broadly categorised into qualitative, quantitative and mixed methods (Saunders *et al.,* 2009). Table 3 presents descriptive findings following a statistical approach. More than half of the sources (53.13%) adopt qualitative methods for the assessment of climate change related issues. Quantitative methods (35.93%) and mixed-methods (10.94%) represent the other half. Qualitative methods were further classified into case studies, interviews/surveys, conceptual/framework development and literature reviews. Likewise, quantitative research methods were categorised into the simulation, mathematical/OR modelling and statistics for better understanding of risk assessment tools and techniques. Numerical, analytical or empirical research approaches were not explicitly classified in the SLR. Within quantitative methods, mathematical/OR modelling was found to be the favoured approach, over simulation and statistical analysis for climate change research. The majority (within 23.44%) of these studies attempt calculating CO_2 emissions within supply chain networks (Cerutti *et al.,* 2016; Fahimnia *et al.,* 2013), identifying the impact of carbon policies on supply chain design (Jin *et al.,* 2014), reducing emissions by pooling supply chains (Pan *et al.,* 2013), and building trade-off models between economic and ecological aspects (Paksoy and Özceylan, 2014). Simulation can be used to discover the impact of different factors and parameters under diverse scenarios. Although the simulation method is not widely used (4.69%), it has been successfully used for identifying the most effective mitigation strategy for climate change (Chen *et al.,* 2015) and selecting the best transportation mode under different logistical parameters (Chen and Wang, 2016). Representative Concentration Pathways (RCPs) are four GHG concentration (not emissions) trajectories adopted by the IPCC can be best modelled following simulation modelling approach. Statistical approaches are primarily used to test the hypothesis.

Table 3. Descriptive analysis

Theme-wise classification	Percentage (%)
Research approach	
Qualitative	53.1%
Quantitative	35.9%
Mixed methods	10.9%
Industry sector	
Specific	54.6%
Diverse	6.2%
Generic	60.9%
Management level	
Strategic	57.8%
Operational	12.5%
Holistic	29.6%
Supply and demand side	
Supply	10.9%
Demand	7.8%

Network	81.2%
Climate change control drivers	
Regulatory	15.6%
Physical	29.6%
Market	3.1%
Resource	7.8%
Combined	43.7%
Mitigation / adaptation approach	
Proactive	64.0%
Reactive	21.8%
Combined	14.0%

In qualitative research, case study is the dominating assessment method accounting for 17.19%, followed by surveys and framework development with 15.63% as shown in Figure 6. A case study approach is believed to be appropriate for areas where knowledge is in the nascent stage (Edmondson and McManus, 2007); and this argument is apt for climate change research in SC context. A mixed-methods approach combining two research methodologies was also identified (10.94%). This hybrid approach taking advantage of the best of both methods has potential for managing climate change related research.

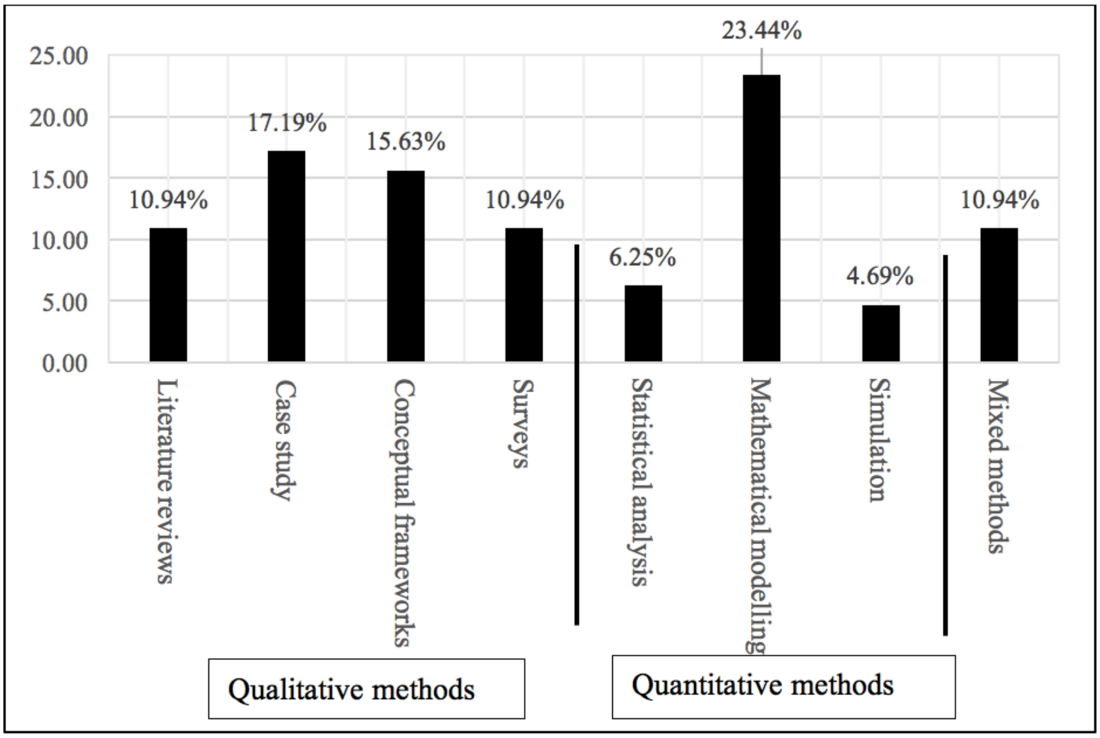

Figure 6. Preferred research methodologies

4.2. Industry Sector

The concentration of climate change research within different industry sectors is captured in Figure 7. The journal papers which do not address the research on a specific industry sector were termed as 'General' whereas other industry sectors (apart from given classification) were grouped under the category 'Diverse'. The majority (60.94%) of studies in climate change do not address any specific industry sector. The research field of climate change is still in an explorative stage; thus studies cover only the broader picture of the specific industry sector. The transportation & logistics sector-focussed studies are noteworthy (12.50%), compared to other sectors as evidenced in Figure 7. This is found to be primarily driven by the physical flow of material between supply chain network and CO_2 emissions generated due to multi-modal transport activities, significantly contributing to climate change. Alternate fuels and transportation modes are explored to overcome some of the challenges faced by climate change in the transportation & logistics sector (Beheshtian *et al.,* 2018; Neumann *et al.,* 2015; Hansen *et al.,* 2015). The food sector is also found to be significantly influenced by the climate change. Changes in temperature, precipitation is found to be negatively influencing crop yields (Conway *et al.,* 2015). Tripathi *et al.* (2016) explored the impact of climate change on major food grain production such as wheat, rice, maize to draw critical insights into impacts and mitigation approaches. Recently, Srinivasan *et al.* (2019) proposed a three-stage approach to guide food sourcing decisions under uncertain environmental changes driven by climate change.

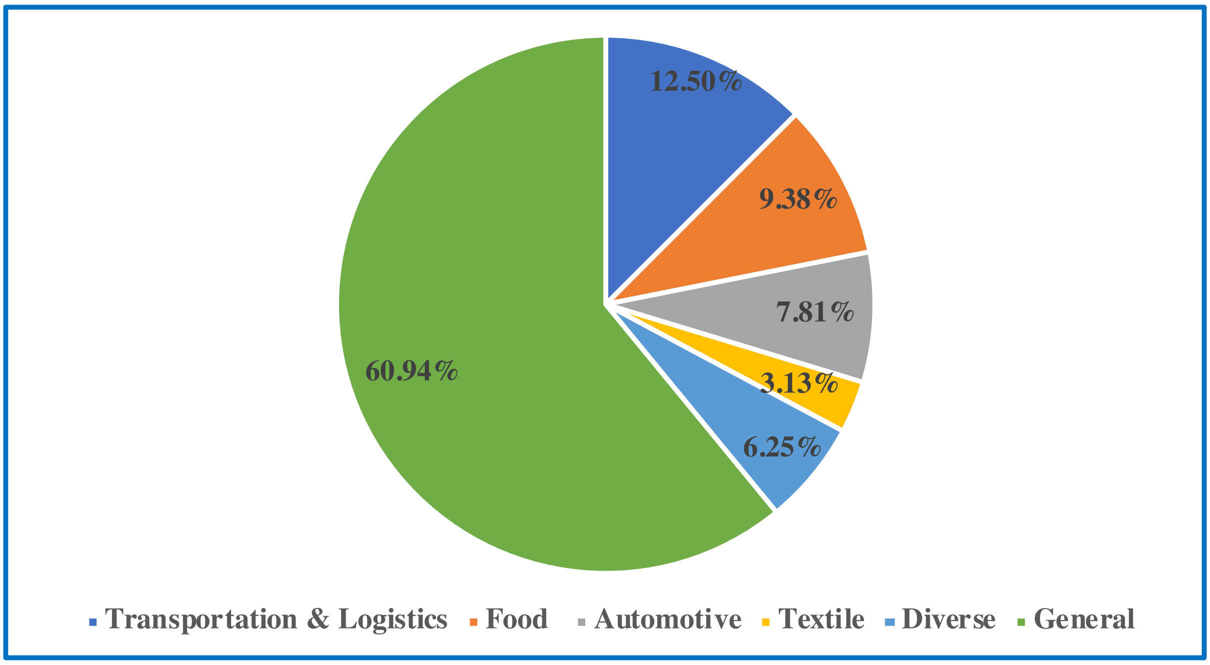

Figure 7. Studied industry and sectors

4.3. Management level

Supply chain management strategies differ depending on the nature of the risk. More than half the papers (57.81%) treat climate change as a strategic level issue within SCM. The key studies include strategic sourcing (Silbermayr and Minner, 2016), supply chain network design (Jin *et al.,* 2014; Mari *et al.,* 2014; Shukla *et al.,* 2011), strategy development for climate change (Lee, 2012; Kirezieva *et al.,* 2015; Halldorsson and Kovacs, 2010), climate change driver identification (Doran and Ryan, 2016), and locating and reducing GHG emissions hotspots (Wolf and Seuring, 2010, Kagawa *et al.,* 2015). The complex structure of a supply chain network with its several members and links across different countries may be an indicator as to why research has, so far, concentrated on strategic issues. United Nations Conference on Climate Change (2015), participating governments published their action plans to reduce GHG emissions by introducing emissions trading schemes, climate change acts, targeting high emission contributing sectors namely manufacturing, transportation, and agriculture. This justifies governments strategic focus on the climate change. The impact of climate change on day-to-day business is summarised under the term 'operational'. Close to one-third studies (29.6%) consider this a holistic problem and thus, attempt to tackle it across levels of management.

4.4. Supply and demand side

This theme attempts to capture the typical sources of climate change. The majority (81.25%) of the research was found to be network-based, with limited (10.94%) studies purely focusing on the supply side and demand side (7.81%) of a supply chain network. Supply-side research includes responding to the natural resource scarcity (Bell *et al.,* 2012; Bell and Mollenkopf, 2013; Nakatani *et al.,* 2015), supplier engagement in the climate change (Jira and Toffel, 2013) and responding to raw-material production under climate change (Kirezieva *et al.,* 2015). Demand-side studies include transport mode selection between a manufacturer and retailer under different emission reduction policies (Chen and Wang, 2016) and facility design under various carbon policies (Jin *et al.,* 2014). It is evident from the study that the scarcity of resources due to natural disasters is influencing the supply side; whereas, use of fossil and non-renewable resources for logistics and warehousing activities is driving the demand side.

5. Thematic analysis

The thematic analysis attempts to answer the research question following a SCRM process and proposed typology. To manage risks, the typical process follows risk identification, risk assessment, and risk mitigation stages. Four basic constructs for defining SCRM are risk sources, risk consequences, risk drivers, and risk mitigating strategies (Jüttner *et al.,* 2003). Thematic findings are presented following these constructs. The section first identifies climate change risk sources, followed by assessment of risks to capture long-term impact and drivers for controlling climate change. Risk mitigation strategies are recognised following proactive and reactive approaches to close the SCRM process cycle.

5.1. Identification of climate change sources

Following descriptive analysis, 54.69% of the research covers 'internal' perpetrators of climate change. GHG emissions are found to be caused by the following sources: transport (Pan *et al.,* 2013), sourcing decisions (Correira *et al.,* 2013), and production/manufacturing (Cerutti *et al.,* 2016; Liu *et al.,* 2012). 35.94% of studies deal with the 'external' perpetrators of climate change such as floods, earthquakes, and tsunamis; meanwhile, the remaining studies (9.38%) cover both internal and external factors. Human activities such as the burning of fossil fuels and unsustainable modifications to the environment cause excessive CO_2 and GHG. Recent natural incidents such as volcanic ash cloud (2010) and California wildfire (2013) are also considerably driving climate change. Deforestation, use of toxic chemicals, and changes in land use are other human-made implications leading to the ozone layer depletion and changing climate (Nema *et al.,* 2012). Climate change is evidently a *'human-induced'* issue and is far more than merely a natural disaster.

5.2. Assessment of climate change

5.2.1 Consequences of climate change

The historical data on precipitation, heatwaves and streamflow shows the increasing trend in global warming (Dai, 2013). One of the significant consequences of climate change is global warming, cascading into droughts as well as floods. This is found to be profoundly influencing food supply chains in terms of food availability (Conway *et al.,* 2015), food loss, and wastage (Devereux, 2007). Furthermore, the mining and logistics sectors will face a significant impact from rising (sea) water levels (Cazenave *et al.,* 2014). As a consequence of climate change, sources of non-renewable sources (e.g. petroleum, coal, natural gas) and metal ores will significantly influence the manufacturing and transportation sectors. Climate change consequences will particularly influence global logistics. Risk to cold supply chain operations is also observed due to rapid changes in the global temperature. Geographical changes driven by climate change are likely to disrupt global supply chains and logistical networks. Reduction in the freshwater sources will impact FMCG products and humanitarian logistics operations. Destruction of manufacturing facilities and transportation networks (Abe and Ye, 2013) and increased insurance premiums (Lash and Wellington, 2007) are some of the short-term consequences of the extreme weather. One of the most critical impacts of climate change on the environment and society will be contamination (pollution) of air, water and food due to rising toxic gases along with increased CO_2 emissions.

5.2.2. Drivers for controlling climate change

Following the review, climate change control drivers are classified into five categories namely, regulatory, physical, market, resources, and combined. Dasaklis and Pappis (2013) propose three control drivers namely, regulatory, physical, and market. 15.63% of the chosen studies focus on regulatory drivers as a control mechanism for climate change risks. Regulatory drivers comprise of rules and regulations set up by policy-makers. Government legislation is one of the key regulatory drivers for climate change control (Long and Young, 2016). Studies on regulatory drivers cover carbon management (Alvarez and Rubio, 2015; Cerutti *et al.,* 2016) and public and government policies (Fahimnia *et al.,* 2013; Jin *et al.,* 2014). They aim to efficiently control pollution and reduce environmental damage in general (Gopalakrishnan *et al.,* 2012). Regulations set by the policy-makers can also lead to innovation and, consequently, provide opportunities for organizations (e.g. carbon credits, circular economy) to increase their competitiveness by investing in new products, processes, and technologies (Bell *et al.,* 2012). Physical drivers attempt to control extreme weather patterns (Abe and Ye, 2013), Although they are difficult to manage and beyond human capacity in several cases, information and communication technology (ICT) is used as a physical driver to inform and proactively reduce/avoid their impact on the environment and society. Early warning systems are commonly used to control potential disruptions to global supply chain networks.

Limited studies cover market drivers, which are mainly motivated by customer pressure and demand for environmentally friendly products. Public procurement can act as a reliable driver for sustainbaility and eco-innovation (Cerutti *et al.,* 2016; Ghadge *et al.,* 2018) and, thus can help to control climate change. Three primary drivers of eco-innovation as per Doran and Ryan (2016) are - demand-side drivers (customers), supply-side drivers (technological and organisational capability), and regulatory drivers (government policies). Market drivers are also driven by supply chain stakeholders involved in the global network. Jira and Toffel (2013) state that buying firms can influence suppliers by engaging them in climate change initiatives. However, their participation strongly depends on company size, profit of industry sector, and country location. A major barrier to climate change is the lack of knowledge about this growing issue (Ng *et al.,* 2016). Nowadays investors and rating agencies demand climate change/risk disclosures from companies (Lash and Wellington, 2007; Wittneben and Kiyar, 2009). Sustainability-focused customer initiatives are needed for controlling the influence of climate change on global supply chains. For example, high levels of environmental pollution, energy consumption and GHG emissions produced by firms can be controlled by the market (customers) and regulatory (Governments) drivers.

The resource dependence of companies and their availability and utilisation is also considered to be a climate change driver. Resource scarcity such as water shortages (Nakatani *et al.,* 2015), security of energy sources and rising oil prices can be seen as immediate challenges for global supply chains (Halldorsson and Kovacs, 2010). Resource scarcity is a driver for organisations to develop control strategies to enhance supply chain performance (Bell *et al.,* 2012) by overcoming some of the above challenges through alternate sources. Lee (2008) states that businesses are more willing to participate in sustainable (social, environmental and economic) supply chain initiatives when organisational capabilities and resources are limited.

Table 4. Drivers and barriers to climate change mitigation

Drivers	Barriers
• Government regulations	• Higher costs
• Public procurement	• Lack of knowledge/awareness
• Rising customer demand	• Lack of support from SC stakeholders
• Technological capability	• Conventional procurement/manufacturing practises
• Stakeholder pressure	• Conflicting business objectives
• Resource scarcity	• Lack of global adaptation strategies
• Economic benefits	• Lack of commitment from governments and society.
• Brand image/reputation	
• Natural disasters	

The term 'combined' is used when studies include more than one climate change driver. The combined effect of customer demand and policymakers' regulations for carbon management is creating pressures for reducing GHG emissions (Nieuwenhuis *et al.,* 2012; Lee, 2012). Brand image motives are another driver for green and ethical sourcing commitments. Micro-level assessment of key drivers of climate change is found to be missing in the current literature. Table 4 presents an overview of all the drivers and barriers identified for controlling climate change from a global supply chain context. Higher carbon costs, conflicting objectives of stakeholders and lack of adequate knowledge and commitment are identified to be key barriers for controlling climate change and associated risks.

5.3. Mitigation of climate change

The risk mitigation approach is broadly classified as proactive and reactive (Ghadge *et al.,* 2013). The prevalent risk mitigation approach is proactive as seen from Table 5. However, most of the reactive mitigation approaches concentrate on natural disasters. Past disasters such as the earthquake in Japan in 2011 (Abe and Ye, 2013; Park *et al.,* 2013; Todo *et al.,* 2015), Thai Flood in 2011 (Okazumi and Nakasu, 2015) and the volcanic eruption in Iceland in 2010 (Stamos *et al.,* 2015) are extensively studied from the reactive mitigation perspective. Although proactive mitigation approaches to minimise vulnerabilities can be far more cost-effective than reactive strategies (Ng *et al.,* 2016), such techniques have not been used efficiently.

Table 5. Generic supply chain risk mitigation strategies

Risk mitigation strategies	References	Classification based on type			
		Generic	*Specific*	*Proactive*	*Reactive*
Low carbon procurement; Green sourcing	Cerutti *et al.* (2016); Correira *et al.* (2013); Gopalakrishnan et al. (2012)		✓	✓	
Cross-docking	Dadhich *et al.* (2014), Ji *et al.* (2014)	✓		✓	✓
Increase vehicle capacity	Dadhich *et al.* (2014); von der Gracht and Darkow (2016)	✓		✓	✓

Carbon-reducing technology	Ji *et al.* (2014)		✓	✓	
Carbon footprint mapping	Lee (2011)		✓	✓	✓
Reducing vehicle speed	Nieuwenhuis *et al.* (2012); Paksoy and Özceylan (2014)	✓		✓	
Alternative fuels	Dekker *et al.* (2012); Wittneben and Kiyar (2009)		✓	✓	
Eco-innovation	Doran and Ryan (2016)	✓		✓	
Supply chain design	Jin *et al.* (2014); Reich-Weiser and Dornfeld (2009)	✓		✓	
Transport mode shift	Jin *et al.* (2014)	✓			✓
Avoidance of single sourcing/use of diversification	Abe and Ye (2013); Park *et al.* (2013)	✓		✓	
Environment-friendly product design	Park, et al. (2013)		✓	✓	
Supply chain and logistics collaboration	Abe and Ye (2013); Becker *et al.* (2013); Dadhich *et al.* (2014); Ramanathan *et al.* (2014)	✓		✓	✓
Avoidance of resource dependence	Bell *et al.* (2012); Nakatani *et al.* (2015); Reich-Weiser and Dornfeld (2009)	✓		✓	
Compliance with environmental standards	Jira and Toffel, 2013)	✓	✓	✓	✓

Ji *et al.* (2014) suggest different GHG reduction strategies for the production, distribution, and disposal phases in a supply chain network. Among other strategies, they indicate that less packaging material would reduce the weight and volume of transported goods and hence reduce GHG. In contrast, an alternative study highlights that less packaging could lead to more transport damage of goods and, consequently, to more reverse transport, thereby resulting in more GHG emissions (Oglethorpe and Heron, 2010). Carbon mapping (Lee, 2011;

Rizet *et al.,* 2012) and environmental hotspot screening (Nakatani *et al.,* 2015) were also identified as useful technique for climate change assessment and proactive mitigation. Cross-docking practices, increases in vehicle capacity, and improvement in warehouse activities are also expected to have a positive impact on GHG reduction (Dadhich *et al.,* 2014). Nieuwenhuis *et al.* (2012) suggest localising supply chains to reduce the GHG caused by transportation. Oglethorpe and Heron (2010) explore whether lean practices can lead to a reduction of GHG emissions. This might be true for postponement strategies and vendor-managed inventory, but practices such as just-in-time inventory can lead to frequent transport (and delays) and hence more emissions (Ugarte *et al.,* 2006). This indicates that lean strategies have to be investigated in detail before implementing them with the aim of emission reduction. A combined lean and sustainable approach may be well-suited for the nature of the problem (Choudhary *et al.,* 2019). Jin *et al.* (2014) highlight a shift to more eco-friendly, sustainable transportation modes. Collaboration between different stakeholders for compliance (with sustainability standards) is found to play an essential role in emissions reduction (Ramanathan *et al.,* 2014; Jira and Toffel, 2013). Table 5 presents a summary of the supply chain risk mitigation strategies identified for climate change. It also classifies identifed risk mitigation strategies based on their wider use within SCs (as general or specific), and on the approach followed by risk managers (proactive or reactive). Near-sourcing, reducing production waste, and optimising transportation operations are some of the key mitigation strategies identified from the literature. Carbon footprint mapping, use of renewable fuels, environmentally friendly design and eco-innovation are some of prominent proactive approaches. Whereas, adherence to sustainability policies/regulations against climate change, recycling Co2, along with carbon tax are reactive approaches.

6. Framework development and agenda for future research

This section provides insights into key findings following descriptive and thematic analysis, followed by developed conceptual framework and identified unique future research directions.

6.1. Key findings

The study addressed research question regarding managing climate change risks in global supply chains. While exploring the nexus between climate change and supply chain management, several research gaps are identified. It is evident that the research on climate change risk in an SCM context, although limited, has constantly been increasing in the recent years. This growing desire to understand the complex interactions of climate change and supply networks is felt post-2010 notably. Furthermore, growing public awareness, government initiatives, media attention and global events such as the Paris Summit (2015) and other conferences/workshops on climate change are found to be solid reasons for the emerging interest. However, despite this trend, the academic literature linking climate change with SCs is fragmented and partial. This is evident through the scattered information in the inter-disciplinary published journals. In terms of research methodology, quantitative methods are favored over qualitative methods for data collection and assessment of climate change; with simulation modelling approach being most preferred for capturing different future climate change scenarios (RCPs). Changes in atmospheric gasses such as CO_2, Methane, Nitrogen dioxide, Chlorofluorocarbons (CFCs) and Stratospheric aerosols are monitored to capture climate change (Hansen *et al.,* 1988). However, majority of the '*greenhouse effect*' is driven by CO_2 emissions alone, thus Carbon dioxide concentrations are found to be a preferred measure for capturing climate change (Rosenzweig and Parry, 1994; Kagawa *et al.,* 2015). However, there are a number of key factors that are also used for measuring climate change ranging from temperature, precipitation, sea level, solar radiations, volcanic activity, biomass and chemical composition. Data triangulation approaches following a mixed methodology have high potential for assessing complex relationships involved in extreme weather patterns and their consequences. Although all sectors are expected to be impacted, only limited sectors, namely food and transportation, are studied comprehensively from a general sustainability perspective. Other sectors such as automotive and mining are also likely to be affected due to regulatory and geographical changes in climate change respectively. SC network design, global procurement, location and transportation related decisions are undertaken at the strategic level of management. However, there is a need for a holistic management approach for mitigating issues associated with climate change in global supply chains. Household recycling, energy consumption, over-processing, waste disposal are few generic operational/tactical issues demanding better management support. No particular focus (either on supply or demand side) on climate change interfacing supply chains related studies is found. Natural resource scarcity, food shortages, external disruptions, facility changes, GHG reduction are commonly explored research topics associated with climate change and SCM.

Transport, outsourcing, manufacturing and mining (for fossil fuels and minerals) are major internal, '*human-induced'* perpetrators of climate change; whereas, floods, earthquakes, and hurricanes are external perpetrators of climate change. These external sources, primarily driven by extreme weather patterns, are increasing in frequency and impact. Climate change and associated risks are found to cascade into SC network following the 'risk propagation' phenomenon. Global warming, a primary consequence of climate change cascades into flood, drought and similar extreme weather 'natural' risks. Thus, climate change is a controllable risk to a certain extent, however few natural events are uncontrollable and beyond the ability of humans. This short and/or long-term impact in terms of shortages, disruptions, delays, and contaminations influence the environmental and social sustainability in SCs. Future global supply chains will feel the cascading influence of them in terms of availability of resources (workforce, energy, raw material). Five control drivers for climate change mitigation namely, regulatory, physical, market, resources and combined are identified. Multiple drivers and barriers to climate change mitigation are identified (refer to Table 4). However, governments, policy makers and end-customers are the key drivers, controlling climate change impact on SCs and the broader ecosystem.

Multiple supply chain risk mitigation strategies for climate change are identified (refer to Table 5). These include carbon mapping (GHG reduction), use of alternate fuels, shift to intermodal transportation, environmentally friendly product design, to name a few. Need to switch to renewable energy sources and embrace sustainable practices is evident through several strategies proposed to mitigate climate change risks in global supply chains.

6.2. Conceptual framework and future research directions

Based on the key findings, a conceptual framework for managing climate change risks in global supply chains is developed. Interestingly, due to emerging nature of literature, the theoretical underpinning to climate change was not found in the literature. However, systems theory has strong links to SCRM literature (Oehmen *et al.,* 2009; Ghadge *et al.,* 2012) and best explains the 'risk propagation' phenomenon of climate change to the broader SC network. As evidenced, climate change and associated risks are interrelated, and they tend to propagate across the global supply chains with a ripple effect. According to systems theory, all the elements are interlinked and influence each other. The theory helps to predict common patterns, behaviours, and properties of complex systems (Checkland, 1981). Supply chains are '*system-of-systems'*, as they meet autonomy, belonging, connectivity, diversity and emergence criteria defined by Gorad et al. (2008) and tested by Choi et al. (2018).

Following a systems theory, all the findings associated and interlinking sources, consequences and control mechanisms for climate change risks are brought together to propose a conceptual framework. Different internal and external sources were identified in the literature. Based on the assessment of sources of this risk, they can be broadly classified into human-induced and natural events. The human-induced sources are driven by ‘internal’ perpetrators such as sourcing, manufacturing, and logistical activities. Meanwhile, the natural sources are driven by ‘external’ perpetrators, typically by natural disaster or an ‘*act of God*’. Heat waves and hurricanes are the leading natural sources influencing global supply chains, as they lead to material shortages and logistical breakdowns respectively. These sources of climate change are presented in the risk identification stage of the framework shown in Figure 8. Multiple quantitative and qualitative assessment tools are used to calculate GHG emission levels and other business influences. In the framework, the long-term impact of climate change is captured as a risk assessment approach, along with the identification of drivers and barriers to controlling climate change. Climate change is found to be propagating into secondary risks before it impacts global supply chains. The evident long-term implications of this evolving risk are global warming, adverse weather, and geographical changes (e.g., rise in sea levels, droughts, etc.), all of which directly impact the performance of logistics and supply chain networks. The risk assessment stage has also identified the driving forces namely regulatory, physical, market, and resources; all of which are trying to control the long-term impact of climate change. Multiple proactive and reactive strategies identified in the study can be implemented to overcome the ever-changing climatic behavior within the risk mitigation stage. Carbon mapping and sustainability practices are some of the proactive approaches; whereas, policies/regulations against climate change along with carbon tax are reactive approaches. Several SCM practices such as collaboration, recycling, remanufacturing, and green sourcing can help to mitigate the impact of climate change to a certain extent. Drivers and barriers for the individual SC network will further determine the mitigation and adaptation efforts to contain climate change risk. Risk identification identifies the sources of climate change. Risk assessment focusses on identified impacts and control drivers. Mitigation and adaptation strategies are captured under the risk mitigation stage of the SCRM.

The framework is developed through holistic synthesis of the literature and identification of key variables of climate change influencing global supply chains. Insights are generated in the form of an SCRM process following systems theory. Building on the identified research gaps and proposed conceptual framework, some of the avenues for the future research are presented.

- ***The link between climate change and other SC risks:*** Within SCRM literature, climate change has received the least amount of attention (Dasaklis and Pappis, 2013). Several human-made and natural disasters are studied extensively within the SCRM literature. However, climate change related extreme weather events, and natural catastrophes are harder to predict (Heckmann *et al.,* 2015) and are least explored. The link between climate change and other SC risks is missing, and the relationship between them is an interesting area for the future research.

- ***Climate change risk propagation****:* It is critical for supply chains to understand the complex behaviour of risk and its cascading impact on the network (Bueno-Solano and Cedillo-Campos, 2014; Scheibe and Blackhurst, 2017; Ghadge *et al.,* 2018). The long-term impact of climate change is found to be propagating from food to manufacturing, to logistics, due to intra-sector network dependencies. The study found climate change and supply chain operations mutually influence each other. The impact of global supply chains on climate change, beyond calculating GHG emissions, is an unexplored avenue. Holistic understanding of climate change and cascading risks is critical. Robust climate change models can be developed to quantify the impact and propose appropriate adaptation strategies.
- ***Sustainable practices for climate change mitigation:*** Several sustainable practices can be implemented to reduce the impact on social and environmental dimensions (Pagell and Shevchenko, 2014). Focused research on mitigating climate change by adopting sustainable practices is likely to reduce the long-term impact of climate change on global supply chains. The impact of implementing sustainability practices on climate change is not explored in the literature. This interconnected link is expected to provide crucial insights into future mitigation strategies.
- ***Approaches for climate change scenarios***: Comprehensive analytical/empirical modelling approaches can be explored to develop climate change scenarios, such as a rise in sea level, cold waves, change in seasons or water scarcity in certain parts of the world. Four distinct future climate scenarios are proposed in the Climate Change 2014 report (IPCC, 2014), but they are based on expected GHG emitted in the years to come. Similarly, scenarios with the use of different renewable energy sources and their broader implications for global supply chains may be useful. Systems theory has the potential for developing simulation models for future climate change scenarios.
- ***Adaptation and supply chain re-design:*** Climate change is inevitable and today's supply chain managers need to adapt by re-designing their networks to build in resilience to unforeseen future disruptions. There is an urgent need to find ways to limit risks through substantial and sustained mitigation actions for climate change (Howard-Grenville *et al.,*

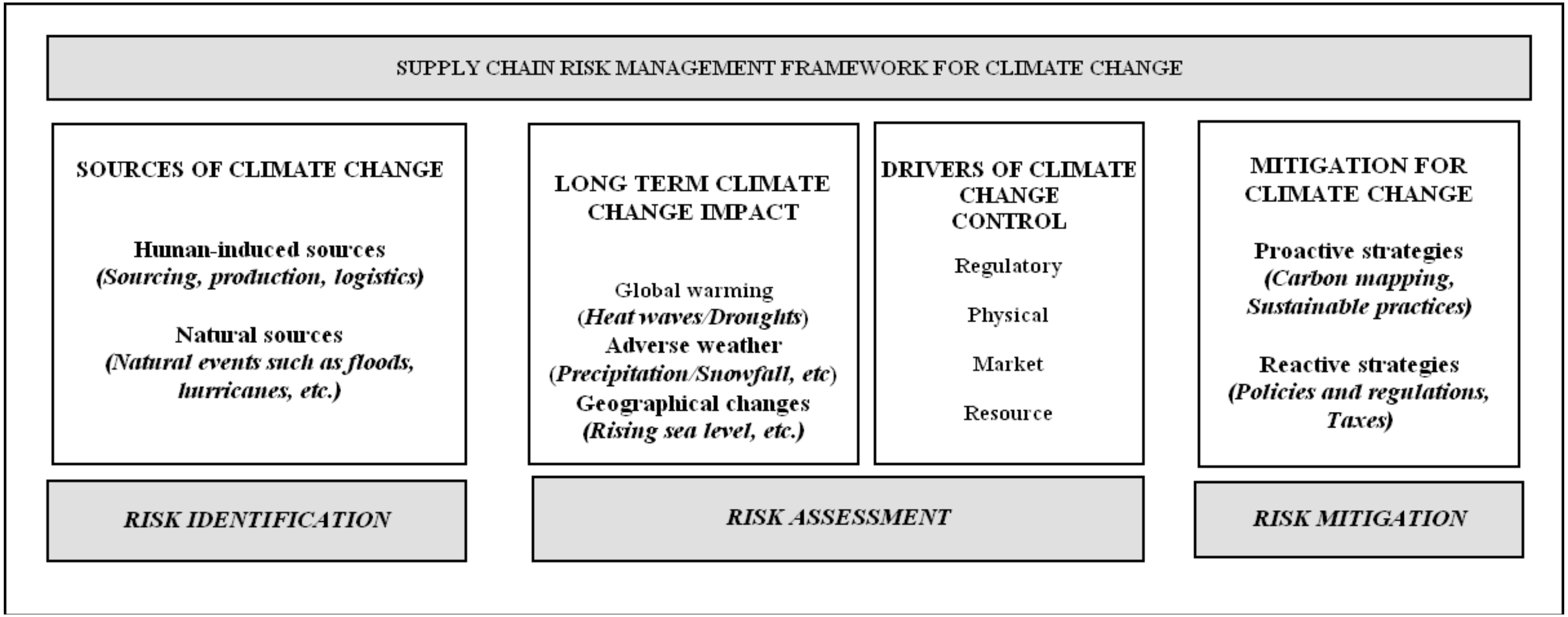

Figure 8. Supply chain risk management framework for climate change risks

2014). Furthermore, the findings indicate that developing innovative drivers for controlling climate change is crucial. Exploring opportunities resulting from climate change is an unexplored area. Melting of ice resulting in the opening of northern sea routes or improved road conditions in Canada may positively affect global supply chain networks. These opportunities would require re-designing of supply chains.

- ***Carbon supply chains management:*** Carbon capture utilization and storage/ sequestration (CCUS) is an integrated suite of technologies which can capture carbon dioxide from waste gases, and store carbon dioxide for long-term for use in industrial processes such as chemical production or enhanced oil recovery (Fanchi *et al.,* 2016). Such initiatives (supported by Governments, policy makers) will help to mitigate climate change risk as well as reduce pressure on use of fossil fuels for energy. Hansen et al. (2015) attempted a network optimization for Carbon capture utilization and sequestration to minimize supply chain cost, while reducing stationary CO_2 emissions. Designing and managing such unique supply chain networks for carbon capture, storage, transportation and usage will be an interesting future research area, we term this as '*Carbon Supply Chain Management*'.

7. Discussion and conclusion

Following a systematic, transparent and replicable literature review process, the study attempted to provide answers to research question- *How can climate change risks be managed in global supply chains?* The development of different typologies for descriptive and thematic analysis captured critical research gaps and recommended multiple future research avenues. Furthermore, following a systems theory, SCRM framework for managing climate change risks is developed.

It is observed that climate change has a significant effect on the demand and supply of goods, food, water, energy and agricultural products. Throughout the study, it was found that climate change and the supply chain are mutually influencing each other. 'Internal' sources are mainly driven by global supply chain operations (production, transportation, overuse of resources) and are responsible for an increase in GHG emissions. Similarly, 'external' sources driven by climate change (e.g. extreme weather conditions, global warming) are negatively impacting supply chain operations in the form of natural disruptions. Use of renewable energy sources such as solar and hydro-powered energy and energy generated from recycled material is likely to reduce the long-term consequences of climate change on SCM. Novel approaches such as re-freezing the poles, ocean greening and recycling CO_2, using modern technologies and processes are also being explored by the global scientists and researchers.

The study advances the existing knowledge in SCRM subject area by providing a comprehensive outlook on climate change in SCM. A combined approach for managing risks and exploring opportunities will lead to a better understanding of SCM in conjunction with climate change (Jira and Toffel, 2013). The SLR is the first within the SCM area focussing on managing climate change risks in a global supply chains context. The research contributes to SCRM literature in two directions. First, it captures a comprehensive picture of climate change and associated phenomenon in terms of sources, consequences, control drivers, and mitigation mechanisms. Vulnerabilities and the cascading impact of climate change risks are captured for SCs by linking it to the systems theory. The study broadens the complex understanding of climate change interfacing global supply chains. Secondly, the SCRM framework for climate change and identified future research directions set a platform for researchers interested in managing climate change risks in different ecosystems. Furthermore, the study is expected to provide inputs towards shaping the emerging literature on SC adaptation for climate change.

It is expected that every business will be affected directly or indirectly due to the climate change risk. Hence, it is imperative for supply chain managers to gain a thorough understanding of how to mitigate and adapt to this emerging threat. The study contributes to practice by providing visibility into the industry sectors most likely to be impacted; their complex association with other supply chain networks. The drivers, barriers, and strategies for climate change mitigation are particularly helpful to practitioners for better managing human-induced risks. To overcome some of the identified propagating impacts, supply chain managers can use alternative sources of energy for producing and delivering physical goods to customers.

The study has used a limited number of papers from inter-disciplinary research areas to address the research question. The inclusion of more papers was limited due to lack of relevant literature discussing climate change within an SC context and stringent screening criteria placed by research team. However, by considering a mix of core and interdisciplinary research journals, the authors hope that the study brings comprehensiveness to the review process. To avoid data analysis being influenced by authors' perceptions, a text mining approach was utilized for data validity. The review spanned 14 years (2005-2018) and followed a rigorous process for the selection of papers from quality journals. Although the selection of papers is not exhaustive, it is believed to be comprehensive, capturing most recent and important developments in the field. Rigorous screening of multidisciplinary academic journals using pre-selected keywords has helped to explore quality literature and disseminate findings in the form of research gaps, future research avenues and conceptual framework. The study provides holistic insights into managing climate change risks in global supply chains. Climate change, in itself, is a vast area for research; however, this systematic literature review is expected to set an evidence-based agenda for future research on climate change in SCM.

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